SPACE ASTRONOMY

OF THE

STEWARD OBSERVATORY

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

CONTROL OF STATIC ELECTRICITY IN 35mm FILM TRANSPORTS UNDER VACUUM CONDITIONS

T 68 - 11

CONTROL OF STATIC ELECTRICITY IN 35mm FILM TRANSPORTS

UNDER VACUUM CONDITIONS

Supported Under NASA Grant NsG - 732

W. G. Tifft
Principal Investigator

E. Nobles
Project Engineer

SPACE ASTRONOMY
of the
STEWARD OBSERVATORY

UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

1 May 1968

T 68 - 11

INTRODUCTION

A chamber to form special photographic test images under controlled conditions was recently fabricated in the Space Astronomy Laboratory of the University of Arizona. In order to eliminate moisture condensation problems at low temperatures the test chamber containing the film is evacuated to about 50 microns pressure. At this reduced pressure severe static electrical discharge problems on the film were encountered as illustrated in figures 1A-1D. Corrective measures, described in the body of this report, were taken to reduce the static discharge problem to an acceptable level as shown in figure 1E.

The test system used in this study consists of the large vacuum chamber mentioned above which houses optical components to produce the test images. A detachable photographic compartment and a monitor photomultiplier with associated electronics are attached to the main chamber. The photographic compartment (see figure 2) contains a pair of 35mm cassette holders, a pair of 35mm sprockets and a retractable platen. The platen, which presses the film against a face plate to determine the focal plane during exposures, is pulled back for film advance and pushed in for exposures. The film is manually advanced, with the passage of film being indicated by a counter attached to one of the sprocket shafts.

GENERAL ANALYSIS

Static discharge does not occur significantly at ambient pressure where accumulated charges readily leak off harmlessly. However, when the film is subjected to a vacuum of about 50 microns, severe static discharge problems are encountered. Experiments indicated a multiplicity of sources which were identified and corrected in turn. Primary sources were found to be (1) film

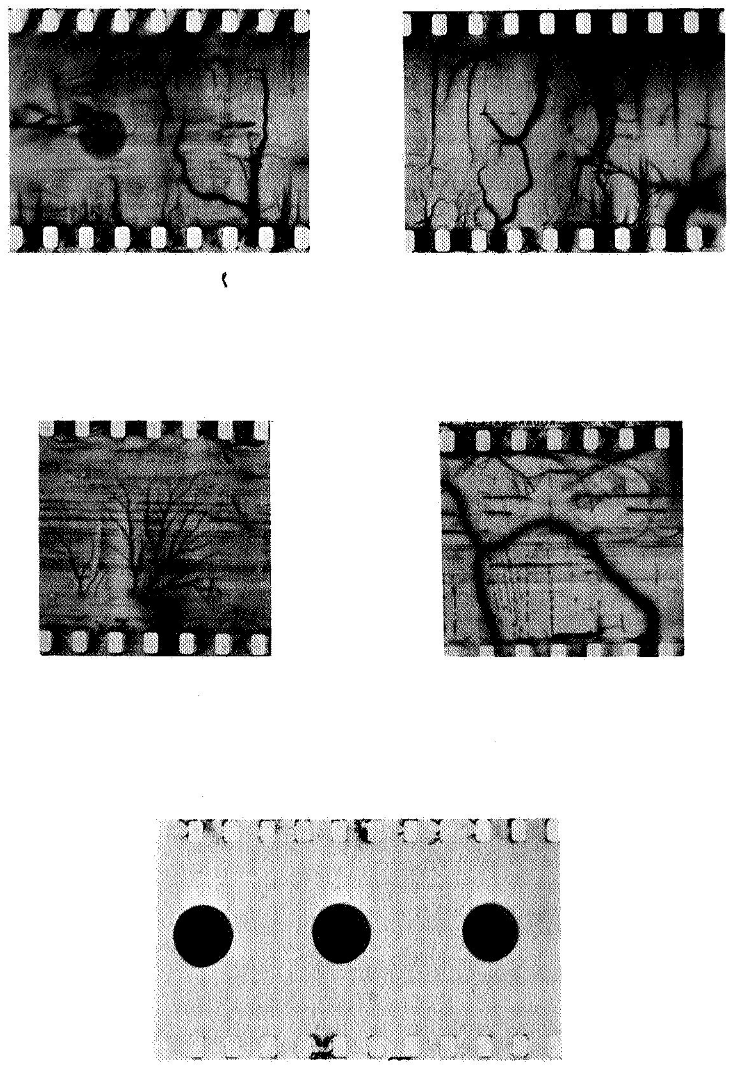
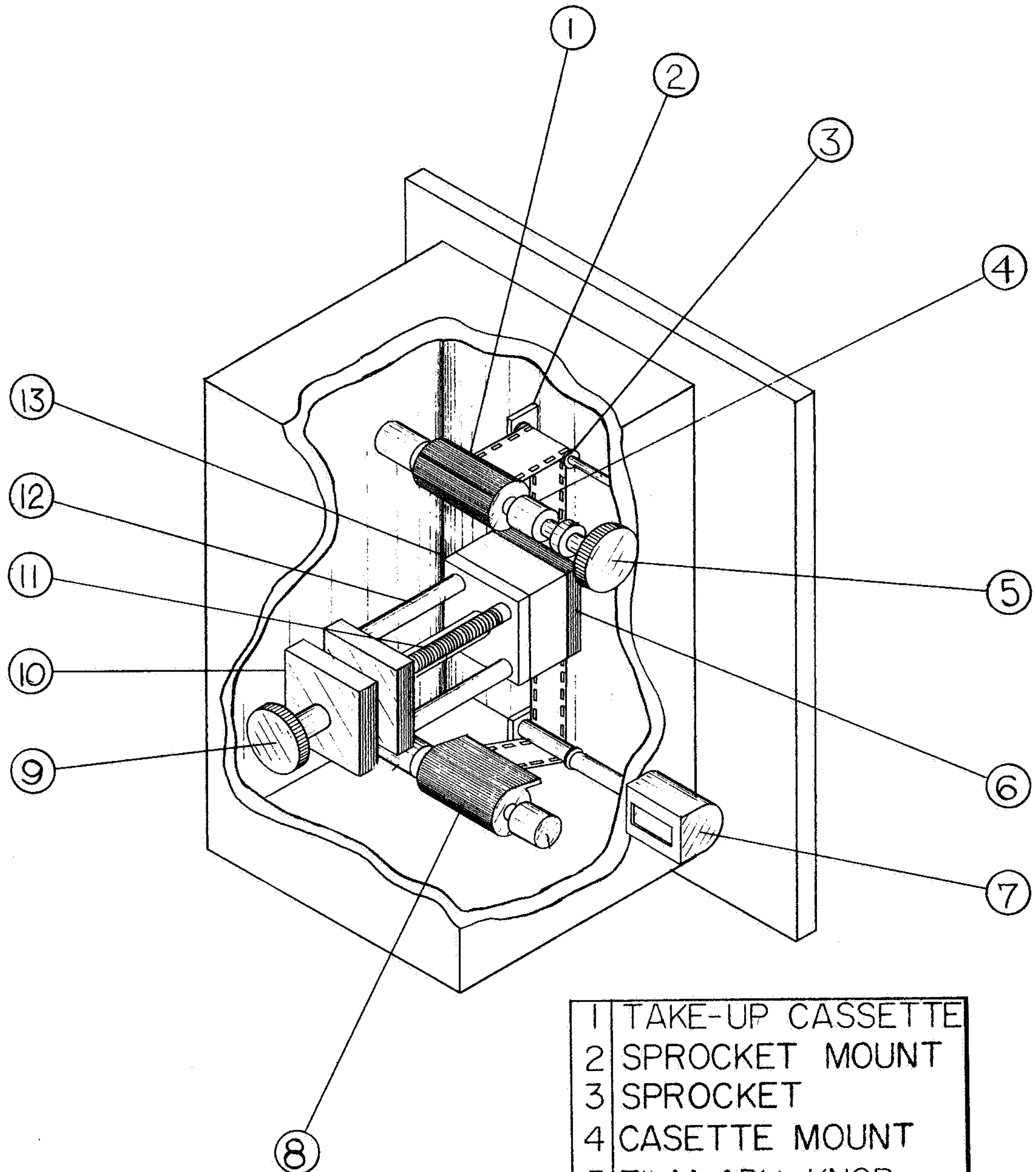


Figure 1



1	TAKE-UP CASSETTE
2	SPROCKET MOUNT
3	SPROCKET
4	CASETTE MOUNT
5	FILM ADV KNOB
6	COPPER PLATEN FACE
7	FILM COUNTER
8	FEED CASETTE
9	PLATEN RETRACT KNOB
10	MOUNTING BLOCKS
11	FLEXIBLE BELLOWS
12	GUIDE PINS
13	S S PLATEN BODY

Figure 2

to cassette, (2) film to ground, and (3) film to film. It was first found that an antistatic spray, Stati-kleer (manufactured by Audiotex division of GC-Electronics, Inc., Rockford, Illinois), applied to the back of the film would eliminate static discharge. The use of the spray was undesirable, however, since, if the problem could be solved directly, the film would not need special treatment other than normal storage and loading. Also, for application within a space flight program, the spray would not be practical, if possible at all. Two possible approaches to a solution were suggested; either furnish the film with an easier, more direct route to ground or isolate the film and those metal parts with which it made contact from ground thereby eliminating a path for the charge accumulation to follow. The charge would then remain on the film until the vacuum was removed or until it slowly dissipated. Due to the local nature of the charge, i.e., charge densities at random sites on the film, the possibility of furnishing a more direct discharge route did not seem promising, so efforts proceeded in the direction of maximum isolation of the film.

FILM TO CASSETTE

It was apparent that one major and easily recognizable source of static discharge came from the slipping of the film through the felt binder on the film cassettes. Certain characteristic "drag" marks (see figure 3) were seen exposed on the film. In figure 3 the horizontal lines are felt "drag" marks while the periodic vertical lines coincide with the distance the film was advanced between frames. Experiments were run using cassettes with the felt sprayed with antistatic spray, but results were negative with a slight worsening of the problem noted. On several cassettes the felt binder was removed and experiments were run using these modified cassettes. Results were positive; static discharges were noticeably reduced although not eliminated. However, handling problems to avoid light leakage became more complicated.

FILM TO GROUND

A primary type of discharge was recognized by a dendritic electrical flow pattern from an area of the film to a point of the sprocket (see figure 4). This pattern did not cross the film entirely and apparently represented a drainage of charge off to ground. In the original system the film sprocket mount made direct metallic contact with the main chassis ground. New mounts were made of Teflon to break the grounding path and subsequent experimentation demonstrated positive results. The general discharge path to ground was thus eliminated.

FILM TO FILM

A semi-dendritic discharge pattern was sometimes observed to run across the film to opposite sprocket holes (see figure 5). This was apparently a flow pattern where the length of the sprocket or metallic film cassette completed a circuit across the film, between points on the film. Note the "reprinting" effect between adjacent film layers in this particular case. This was corrected by the insertion of a dielectric spacer between the sprocket gear ends to prevent discharge across the width of the film. A similar discharge was observed between sprocket teeth at the edge of the film (see figure 6). This was corrected by Teflon coating of the sprockets themselves to avoid discharge between the teeth on the sprocket. Again, results were generally positive and the major static discharge problems were eliminated. Some small discharge effects are still occasionally seen at the edges well away from the exposed area. Under circumstances where the film cassette may form a conduction path between film points a non-metallic or coated cassette is required.

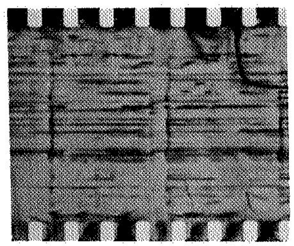


Figure 3

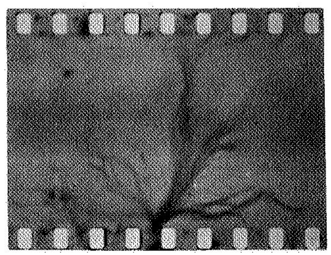


Figure 4

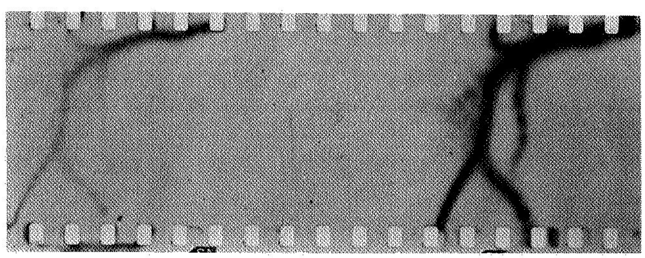


Figure 5

Examination of exposed film indicated that in some cases there might be diffuse discharge of one area of film to itself due to contact in the cassette upon rolling up. As long as the charge is not actually removed from the film before rolling, there is no obvious solution to this problem. An article in SPIE - GLASS (volume 3, no. 9 Feb. 1968, p.28) announced the development of a special Kodak UV film which has a coating of "rails" along the edges. These rails prevent the film from contacting itself and is reputed to prevent fogging or unwanted development on sensitive films. It should also be effective in reducing or localizing film to film contact discharge. Slippage of the film upon itself in winding must be avoided.

<u>FILM TO PLATEN</u>

During several experiments the metal platen was charged to a potential of 1000 VDC. The platen itself is isolated from ground, so no direct discharge to ground can occur through it. Results indicated that this contributed no discharge to the film except when the polarity was suddenly reversed inducing a sudden charge displacement and producing a weak diffuse granular fogging (see figure 7). During some of these same experiments, the platen was deliberately moved in and out several times to separate effects of film to platen electrical discharge and the effect of direct platen pressure on the exposure of the emulsion. At ambient air pressure no fogging was observed, but under vacuum, examination of exposed films indicated a discharge to the platen in specific locales as noted by the two sharp discharge points to the left of each spot exposure in figure 8. These coincide with specific portions of the platen during exposure. The platen face has since been polished.

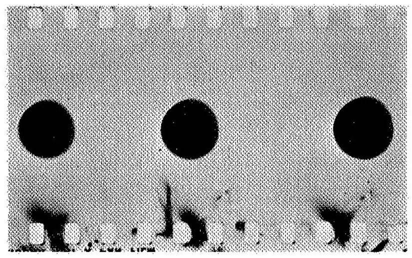


Figure 6

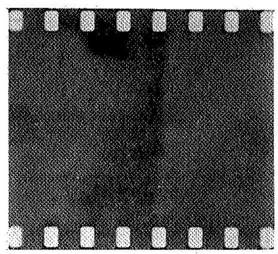


Figure 7

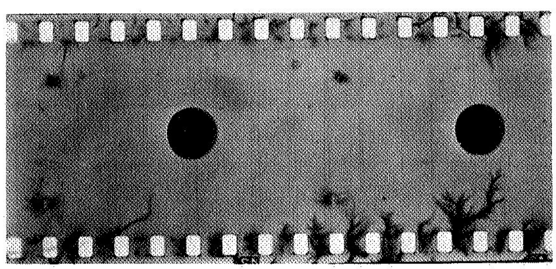


Figure 8

OTHER EFFECTS

Examination of film strips also disclosed a fine-line structure generally extending across the film from one sprocket hole to the opposite sprocket hole (see figure 9a). These lines do not appear to be directly related to the type of static discharge discussed above since they were as abundant on strips which were relatively free of other static discharge as on those which had numerous discharges. Since there were very few (but some) of these lines on strips exposed at ambient pressure, the lines are quite possibly induced indirectly through vacuum "welding" or binding of the bearing surfaces of the cassette holder or the sprockets which rotate on shafts. This vacuum lubrication binding causes a frictional drag which places the film under increased strain when driven around the sprocket under the vacuum conditions and may cause the emulsion to crack slightly. Film advance under vacuum conditions was considerably more different due to this binding. Figure 9b-d shows photomicrographs of lines. They are intensely exposed along the line and almost always originate at sprocket points which often show fogging due to local sprocket tooth pressure. Vacuum lubricant has been applied to all suspect surfaces, but the effectiveness of this measure is not yet known. It is likely that proper lubrication and minimization of film flex angles will control this problem.

SUMMARY

Proper film transport design alone will go a long way toward elimination of static electrical discharge on film in a vacuum. The following basic rules should accomplish effective controls:

1) Avoid film slippage over any surfaces; transport the film with firm but minimal insulated contact at the sprockets and wind film without slippage on itself.

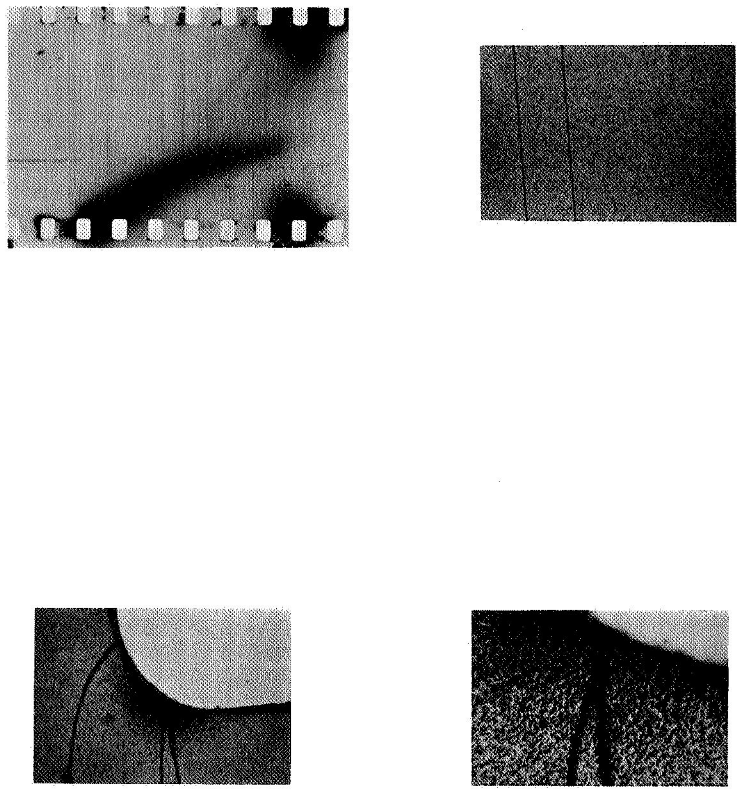


Figure 9

2) Avoid all possible contact of film with conductor. Where this is not possible polish contact surfaces to minimize point discharge sources. Isolate from ground any metallic components which closely contact the film.

3) Minimize film bend angles and provide careful vacuum bearing design to reduce film stress to a minimum.

In addition to transport design, the choice of film base and backing can be expected to effect static discharge. Where additional protective margin is possible, it should be utilized; however, the present study suggests that careful transport design alone can control any severe problem.